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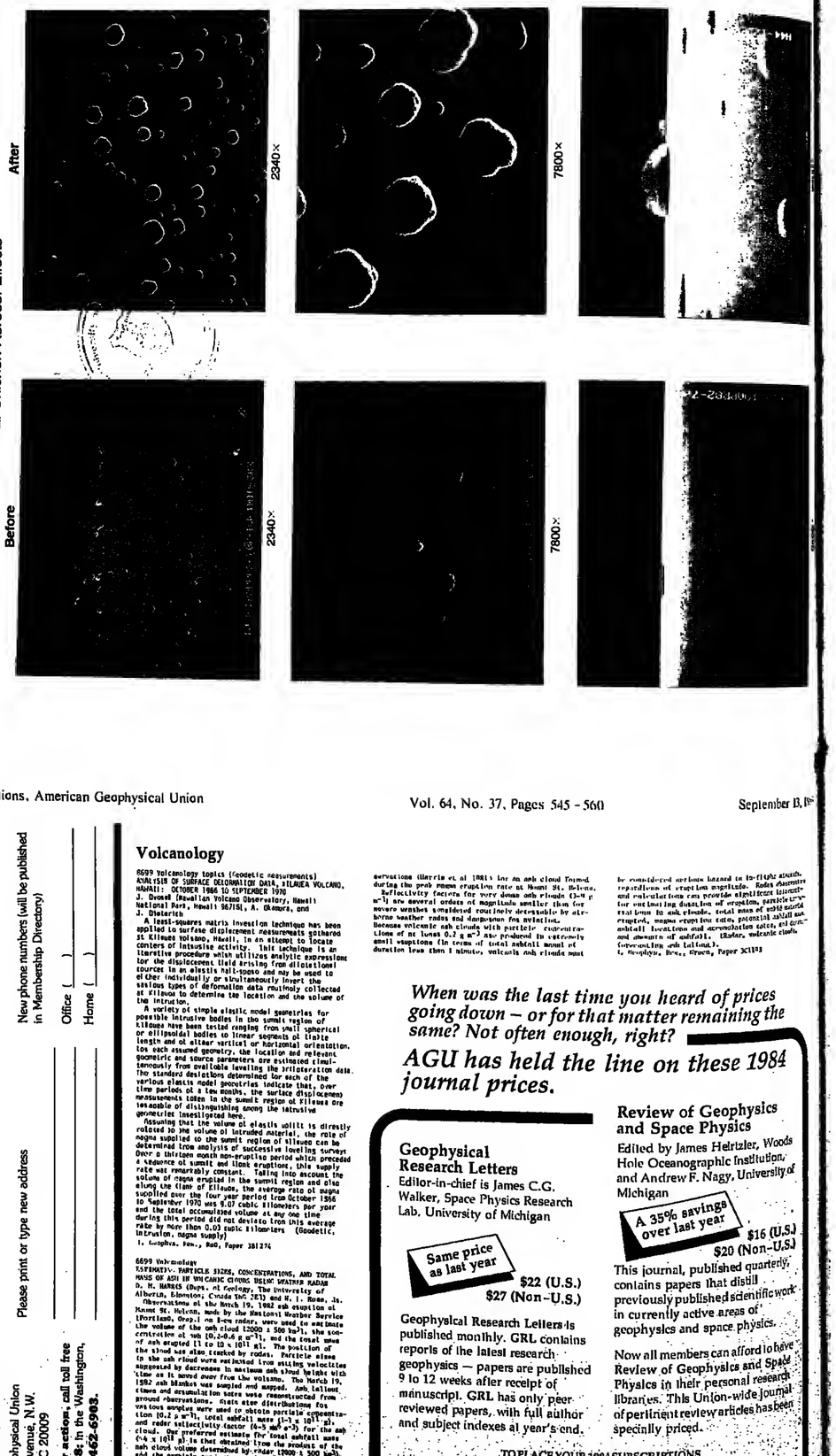
El Chichón Aerosol Effects



EOS, Transactions, American Geophysical Union
Vol. 64, No. 37, Pages 545 - 560
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Volcanology

6699 Volcanology topics (Geodetic measurements)
AVAILABILITY OF SURFACE DEFORMATION DATA, KILAUEA VOLCANO, HAWAII: OCTOBER 1966 TO SEPTEMBER 1970
J. Dvorak (Hawaiian Volcano Observatory, Hawaii National Park, Hawaii 96718), A. Okamura, and J. Dieterich

A least-squares matrix inversion technique has been applied to surface displacement measurements gathered at Kilauea volcano, Hawaii, in an attempt to locate centers of intrusive activity. This technique is an iterative procedure which utilizes analytic expressions for the displacement field arising from dilatational sources in an elastic half-space and may be used to either individually or simultaneously invert the various types of deformation data routinely collected at Kilauea to determine the location and the volume of the intrusion.

A variety of simple elastic model geometries for possible intrusive bodies in the summit region of Kilauea have been tested ranging from small spherical or ellipsoidal bodies to linear segments of finite length and of either vertical or horizontal orientation. Tests each assumed geometry, the location and relevant geometric and source parameters are estimated simultaneously from available leveling and trilateration data. The standard deviations determined for each of the various elastic model geometries indicate that, over time periods of a few months, the surface displacements measured taken in the summit region of Kilauea are not capable of distinguishing among the intrusive geometries investigated here.

Assuming that the volume of elastic solids uplift is directly related to the volume of intruded material, the rate of magma supplied to the summit region of Kilauea can be determined from analysis of successive leveling surveys. Over a thirteen month non-eruptive period which preceded a sequence of summit and flank eruptions, this supply rate was remarkably constant. Taking into account the volume of magma erupted in the summit region and also along the flank of Kilauea, the average rate of magma supplied over the four year period from October 1966 to September 1970 was 9.07 cubic kilometers per year and the total accumulated volume at any one time during this period did not deviate from this average rate by more than 0.03 cubic kilometers. (Geodetic, intrusion, magma supply)
J. Geophys. Res., 88B, Paper 3B1274

6699 Volcanology
ESTIMATE OF PARTICLE SIZES, CONCENTRATIONS, AND TOTAL MASS OF ASH IN VOLCANIC CLOUDS USING WEATHER RADAR
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Observations of the March 19, 1982 ash eruption of Mount St. Helens, made by the National Weather Service (Portland, Oregon) 10-cm radar, were used to estimate the volume of the ash cloud (2000 ± 500 km³), the total concentration of ash (0.2–0.6 g m⁻³), and the total mass of ash erupted (1 to 10 × 10¹¹ g). The position of the cloud was also tracked by radar. Particle sizes in the ash cloud were estimated from settling velocities suggested by decreases in maximum ash cloud height with time as it moved away from the volcano. The March 19, 1982 ash blanket was sampled and mapped. Ash fallout times and accumulation rates were reconstructed from ground observations. Plots of ash distribution for various eruptive were used to obtain particle concentration (0.2 g m⁻³), total ash mass (3–5 × 10¹¹ g), and radar reflectivity factor (6–5 mm⁶ m⁻³) for the ash cloud. Our preferred estimate for total ashfall mass (4 × 10¹¹ g) is that obtained from the product of the ash cloud volume determined by radar (2000 ± 500 km³), and the particle concentration inferred from ashfall data (0.2 g m⁻³).

Ashfall data for the May 18, 1980 Mount St. Helens eruption has been actually using our ashfall inversion technique to estimate 3-hour mass particle concentration (1 g m⁻²), the size distribution, total ashfall mass (8 × 10¹¹ g), and radar reflectivity (between 17–60 mm⁶ m⁻³) for the ash cloud. A binary value (5 g m⁻²) for particle concentration was obtained from radar observations (Harris et al. 1981) for an ash cloud formed during the peak plume eruption rate at Mount St. Helens.

Reflectivity factors for very dense ash clouds (2–3 g m⁻³) are several orders of magnitude smaller than for severe weather considered routinely detectable by airborne weather radar and dangerous for aviation. Because volcanic ash clouds with particle concentrations of at least 0.2 g m⁻³ are produced in extremely small eruptions (in terms of total ashfall mass and duration less than 1 minute), volcanic ash clouds must be considered serious hazard to in-flight aircraft, regardless of eruption magnitude. Radar observations and calculations can provide significant information for continuing duration of eruption, particle transport from ash clouds, total mass of solid material erupted, mass eruption rates, potential ashfall and ashfall locations and accumulation rates, and generation and amounts of ashfall. (Radar, volcanic clouds, forecasting, ash fallout).
J. Geophys. Res., Oceans, Paper 3C1183

NASA Global Tropospheric Experiment

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A major research effort, the Global Tropospheric Experiment (GTE), has been initiated by the National Aeronautics and Space Administration (NASA) to study the chemistry of the global troposphere and its interaction with the stratosphere, land, and oceans. The project currently involves approximately 20 principal investigators from 16 different institutions and is expected to expand over the next decade. The first phase of the project is aimed at developing and validating measurement techniques for trace species in tropospheric chemical cycles. It is designed to lead toward development and implementation of a cooperative research program involving NASA, scientists sponsored by the National Science Foundation, the National Oceanic and Atmospheric Administration, other government agencies, and research institutions abroad. The goal of the GTE is to understand the chemical cycles that control the composition of the global troposphere and its changes.

The NASA GTE is managed through the Tropospheric Chemistry Program in the Earth Science and Application Division of the Office of Space Science and Applications. It has evolved from the recommendations of a series of scientific working groups composed of more than 100 members of the atmospheric sciences community. The immediate emphasis of the GTE is on the development, testing, and evaluation of measurement techniques that can achieve, under field conditions, the extreme sensitivity required to measure atmospheric concentrations of key chemical species, which can in some cases reach as low as 10^5/cc and still exert great influence on the global tropospheric composition. The second phase of the GTE will focus on widespread, systematic measurements supported by modeling and laboratory studies to understand the principal processes that govern key chemical cycles in the troposphere. A major element of the second phase of the experiment will be an aircraft sampling program to characterize global distributions and fluxes of numerous tropospheric trace species.

The third phase of the Global Tropospheric Experiment is anticipated to begin in the early 1990's and will focus on global scale investigations of principal tropospheric chemical and transport processes with space-based measurement as a major tool. Many of the mission and design specifications for tropospheric chemistry measurements from space would be formulated on the basis of results of the aircraft studies, supported by extensive modeling.

Scientific Rationale

Human activities have reached a scale sufficient to impact the atmosphere on a global scale, with the best known examples being increasing levels of CO_2 related to fossil fuel combustion and the probable depletion of stratospheric ozone through photochemistry based on nitrogen and halogen compounds (N_2O and chlorofluorocarbons). Other gases, such as CH_4 and N_2O, are also believed to be increasing, based on preliminary data from ambient air monitoring combined with studies of fossil gases in ice cores. A variety of photochemical, biological, and climatic factors influence sources and sinks for atmospheric species of carbon, nitrogen, and sulfur. The goal of the Tropospheric Chemistry Program is to increase our understanding of chemical and physical processes that control the composition of the atmosphere with special emphasis on the potential global impact of human activities. The role of the global troposphere as the source and sink for substances in the stratosphere, the details of the troposphere/stratosphere interchange, and the process that control global tropospheric ozone are of particular interest to NASA, as is the eventual development of enhanced capability to study the troposphere and its composition from space.

At NASA's request, a scientific Working Group, headed by John H. Seinfeld of the California Institute of Technology, undertook a major effort in 1978–1980 to identify scientific objectives and make recommendations on appropriate research and development tasks that NASA should undertake to contribute to an understanding of tropospheric chemistry and to begin the development of space-based systems to study it. The Working Group's findings have been published as *NASA Reference Publication 1062*, "Report of the NASA Working Group on Tropospheric Program Planning." The Working Group recommended that NASA expand its ongoing tropospheric research program to provide the critical information needed for more complete understanding of the atmosphere on the regional to global scale where space-based measurements appear to offer the most promising advantages in the long run. The Working Group recommended the following scientific goals of the program:

1. Establishment of global atmospheric concentration distributions and budgets of those elements and compounds believed to be of key importance in global biogeochemical cycles.
2. Determination of the cause-and-effect relationships between these observed distributions and dominant controlling factors, such as atmospheric chemical transformations, biospheric and atmospheric source and sink strengths, and atmospheric transport.

To achieve these goals, the Working Group recommended a broad program of investigations in four Tropospheric Chemistry Program elements: modeling and data analysis, laboratory studies, field measurements, and technology development.

A second scientific working group was convened in July 1981 to identify specific research tasks related to the development and use of modeling in the design of global tropospheric field experiments. The results of this working group are published as *NASA Conference Publication 2293*, "Applying Modeling Results in Designing a Global Tropospheric Experiment." The principal findings reported in this document are as follows:

1. The chemical species most critical to advancing the understanding of homogeneous gas-phase chemistry of the troposphere include OH, NO, and NO_2. Techniques for measurement of these species in the nonurban, remote atmosphere are under development but have not yet demonstrated satisfactory accuracy or precision. Completion of instrument research, development, and testing for measurement of OH, NO, and NO_2 in the remote troposphere is a top-priority activity.

2. There is a second group of gaseous chemical species, including CO, CH_4, O_3, N_2O, halogens, certain trace metals, and reduced sulfur species, for which it is possible to make accurate, precise measurements both on the ground and from aircraft. The global concentration distribution of these species needs to be determined. Any field program should include both ground measurements and vertical profiles of these species. Data on seasonal variability at specific sites and interhemispheric concentration gradients for these species are of particular importance.

3. Working group members concerned with measurements in the boundary layer placed strong emphasis on the need to develop capabilities for direct measurement of chemical fluxes between earth surface sources and sinks, the boundary layer, the free troposphere, and the stratosphere. A recommendation was made that additional fast-response chemical sensors be developed to increase capabilities for airborne flux measurements, with emphasis on particular needs for flux data on O_3, CO, CO_2, CH_4, NH_3, N_2O, nonmethane hydrocarbons, and gaseous reduced sulfur species over oceans, tropical forests, wetlands, and areas of biomass burning.

4. To quantify global tropospheric budgets of chemical species such as O_3, NO, NO_2, and H_2O, exchange between the troposphere and stratosphere must be investigated in detail. The working group on stratosphere-troposphere exchange recommended a program of field measurements in mid-latitude tropause fold structures; these are regions of active stratosphere-troposphere exchange and large chemical gradients. Meteorological techniques using potential vorticity can be used to guide aircraft chemical sampling and to extrapolate results to global fluxes. A second region of particular importance for assessing troposphere-stratosphere exchange is the Intertropical Convergence Zone, where high altitude cumulus towers penetrate the tropopause.

5. In the area of modeling research needs for global tropospheric studies, the working group stressed the need for emphasis on the development of coupled dynamic-photochemical models to explore the global budgets of O_3, CO, and other critical chemical species. One-dimensional and two-dimensional models will continue to play a critical role in regional transport and geochemical budget studies and also in exploring new chemical reaction schemes.

6. Longer-range goals for a global tropospheric research program must include understanding the role of complex heterogeneous process in global budgets. The working group recognized that while extensive research is currently in progress on regional air pollution chemistry, studies of heterogeneous processes in remote, nonurban tropospheric regions are in the very early stages of development. In the next few years, particular emphasis must be placed on the development of both collection and analytical techniques for ground and airborne measurements of gas-particle reactions, precipitation scavenging processes, and chemical deposition in oceanic and remote continental regions.

7. The working group stressed the importance of careful research into the monitoring of long-term trends in long-lived tropospheric trace gases such as CO_2, CH_4, N_2O, and certain halocarbon species. It was felt that NASA should explore its potentially unique role for developing space techniques for long-term monitoring of the global troposphere.

NASA has responded to the recommendations of the working groups by directing its ongoing Tropospheric Chemistry Program toward a coordinated research effort to meet the recommended scientific goals. The investigations that make up this research program are collectively referred to as the Global Tropospheric Experiment.

Research Program

GTE Phase I: Chemical Instrumentation Test and Evaluation (CITE)

The principal thrusts of the first phase of the GTE include new and expanded investigations aimed at the development of advanced technologies for measurement of OH, NO, and NO_2 and other key trace gases and aerosols.

During this first phase of the Global Tropospheric Experiment, investigations will emphasize (1) improvements in instrument detection limits for measurement of the very low concentrations of OH, NO, and NO_2 en-

Article continued on p. 562

Forum

The Etymology of "El Chichón"

The eruption of El Chichón in the state of Chiapas, Mexico, in spring 1982 is clearly an important event for the study of volcanic effects on climate. Many reports have already appeared describing properties of the dust cloud [*Robock*, 1983], and comparisons of observed and calculated atmospheric effects have been undertaken [e.g., *Quiroz*, 1983]. We have meanwhile noted confusion regarding the meaning of the name of the volcano, and it is the intent of this note to clarify this problem.

One meaning given in various dictionaries—easy, presenting no problem; teasing, joke-playing (Central and South America)—seems irrelevant and will not be treated further here.

Robock [1983] states that "El Chichón" in Spanish means bump or swelling from blow to the head; also, bruise; from Latin *abscesus*, tumor. (Source: Spanish Royal Academy, *Diccionario de la lengua española* (18th ed., 1956). Note: A remote English cognate for chichón is therefore *abscess*.) Indeed, this is the only definition carried in the Spanish Royal Academy's *Diccionario*. However, Spaniards and Latin Americans whose vocabulary goes beyond the dictionary are aware of other connotations, and some will readily refer to the highly popular, mildly erotic use of the word given in *Santamaría* [1959]: Augmentative formed from *chiche*, which means mammary gland or nipple. Feminine counterparts of chichón and another derivative, *chichada*, are *chichona*, *chichada*, meaning, for example, a heavily-endowed woman. (Note: Chiche, or chichi, or chicha, is from the Basque *txitxa*.) Indeed the association of this meaning with the volcano has been suggested in a lively letter to Robock from the British Ambassador to Mexico, Sir Crispin Tickell (February 28, 1983), citing no less an authority than the former President of Mexico, Jose Lopez Portillo. Ahal

Careful research, however, leads to a different conclusion. The scholarly and comprehensive *Diccionario de Mexicanismos* [*Santamaría*, 1959] points to a more logical direct meaning for "El Chichón": The name given by the people of the states of Chiapas and Tabasco to a most beautiful palm plant (*Exopetion mexicanum, Liebm.*) which grows to more than 2 m in height on the mountainsides, bearing a delicious-tasting, spindle-shaped fruit about 10 cm long. A *chichonal* is an area with these palms. (Note: According to *Medina* [1982], the fruit itself has the name of "chichón.") That this is the proper meaning to be associated with the volcano has been confirmed by Ignacio Galindo, Director of the Mexican Institute of Geophysics (private communication, 1983), who further called attention to the documentation by *Medina* [1982], from which I quote, in translation:

"The area near the volcano presented a great abundance of a species of palm, *Astrocaryum Mexicanum Liebm*, whose fruit is named chichón, which is the basis for naming the volcano Chichón or Chichonal [see *Santamaría*, 1959]. It is appropriate to note that the official name assigned in the Catalog of Active Volcanoes of the World, published in 1958, is that of Chichón."

Thus it is clear that "El Chichón" refers to the palm, or its fruit, identified by Santamaría. The shape of the fruit described by Santamaría further raises the possibility, to this writer, that the fruit itself may have been named with Santamaría's other meaning (mammary gland) in mind. In situ discussions with some of the older inhabitants of Chiapas may be needed to resolve this aspect of the problem.

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Article *(cont. from p. 561)*

countered in the remote troposphere; (2) improvements in response time of measurement systems to enhance our capabilities for coupling chemical sensors to meteorological sensors for improved flux determinations; (3) expansion of our measurements capability to key tropospheric species for which we currently have no suitable measurement techniques; (4) expansion of the range of validity of laboratory measurement techniques to conditions encountered in field measurements; and (5) establishment of reliable absolute calibration procedures for instruments measuring key tropospheric species and intercomparisons of different instruements that can measure the same species in an effort to identify and correct any systematic errors.

The scientific objectives of the Global Tropospheric Experiment require concentration and flux data over a range of temporal and spatial scales. To accomplish these objectives requires a combination of remote and in situ systems for both ground and airborne measurements.

Measurement Technique Intercomparisons: 1982–1984

An ad hoc Scientific Steering Committee was established in 1982 to develop a detailed strategy for evaluation of the advanced measurement techniques mentioned above. The committee recommended a three-step test and evaluation program involving a ground-based intercomparison, an airborne intercomparison in the tropical troposphere with particular attention to the boundary layer over the ocean and over tropical forests, and an airborne intercomparison in the upper troposphere. This strategy will systematically expose the measurement systems under current development and evaluation to conditions which will be encountered in GTE phase 2 field experiments. Particular attention will be given to assessing the effects of potential interferents in the measurement of OH and NO.

The principal investigators for the NASA GTE/CITE are Malcolm J. Campbell, Washington State University, OH-Radiocarbon Tracer; Charles C. Wang, Wayne State University, OH-Laser Induced Fluorescence, Liidar; Douglas D. Davis, Georgia Institute of Technology, OH-Single Photon, Laser-Induced Fluorescence, in situ and NO-Two Photon, Laser Induced Fluorescence, in situ; Mack McFarland, NOAA Environmental Research Laboratories, and Brian A. Ridley, National Center for Atmospheric Research, NO-Chemiluminescence; Arnold L. Torres, NASA Wallops Flight Center, NO-Chemiluminescence; and James M. Hoell, NASA Langley Research Center, CO-Laser Differential Absorption.

The ground-based measurement technique evaluation took place at the NASA Wallops Flight Center, Wallops Island, Va., in July 1983. In addition to simultaneous measurements of OH and NO, a wide range of meterological and chemical parameters are being analyzed to assist in the interpretation of any differences which may be reported by the several techniques measuring OH and NO. This activity will also result in one of the most comprehensive air chemistry data sets ever obtained at a nonurban location and will constitute the first effort to intercompare advanced instrumentatin for detecting the extremely low concentrations of OH and NO found in the remote troposphere.

Following the ground-based evaluation in a coastal environment, the second step in the program will be airborne measurement technique evaluations in and above the tropical boundary layer. The tropical portion of the program will operate from Barbados. These flights could take place as early as November 1983, depending un the results of the July ground-based measurement technique evaluation. Intercomparison flights are planned over the tropical Atlantic Ocean and over tropical forests of South Americn. These flights will expose the instruments being evaluated to a wide range in water vapor, arine and continental aerosol, and natural hydrocarbon concentrations. A NASA CV-990 aircraft platform will carry the advanced instruument systems being evaluated together with associated supporting measurements of meteorological and chemical parameters (water vapor, temperature, aemsol particle size and chemistry, hydrocarbons, etc.).

The final step of the measurement technique evaluation program will be conducted in the upper troposphere, over the U.S. midcontinent, possibly as early as spring 1984. This airborne intercomparison will use tropopause fulding events to expose the measurement techniques being evaluated to a wide range in concentrations of ozone and other key species of the upper troposphere. The preliminary plans call for this instrument intercomparison flight to be conducted simultaneously with U2 flights in the lower stratusphere as part of a major field study of stratosphere/troposphere exchange.

At the end of these three intercomparison activities, NASA plans an intensive annlysis of the results that will provide guidance for the selection of the experimental techniques to be deployed in systematic measurement campaigns planned for later in this decade.

Additional Studies

The immediate primary objective of the global tropospheric modeling efforts are to identify key areas of uncertainy in the understanding of tropospheric chemistry and transport, to develop measurement requirements for field investigations, and to aid in the development of an optimal global sampling strategy for the extensive field measurements campaign project that will highlight the second phase of the GTE. The existing array of photochemical and dynamic models will be used to estimate spatial and temporal scales of importance in both the natural and perturbed troposphere. Anthropogenic and changing natural activities that might play major roles in perturbing the chemical budgets of the troposphere will be studied. These results will be used to guide the selection of individual experiments, the combination of experiments on common measurement platforms, and the overall sampling strategy that would be used in the second phase of GTE.

To accomplish the above objective, the state of the art in global-scale tropospheric modeling itself must be advanced. It is anticipated that near-term modeling research will include two primary objectives. First, an increasing degree of sophistication will be incorporated into the treatment of physical and biological processes in current models; and second, the treatment of couplings between chemistry and transport, such as troposphere-stratosphere exchange, will be explored in more detail.

Continued planning of phases 2 and 3 of the GTE will require input fmm the scientific community nn optimum design of global tropospheric field of new measurement techniques for many extremely important trace gases. Research needs related to flux measurement, heterogenous processes, global scale cloud chemistry, and related topics still remain to be specified in detial and will be the topics of Working Group meetings in the near future.

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John P. Mugler, Jr., *received his B.S. in 1949 and his M.S. in 1958 in aeronautical engineering from Virginia Polytechnic Institute and State University. He conducted research in aerodynamics and spare environmental effects with NACA/NASA and the U.S. Air Force from 1950 until 1976 when he assumed management responsibilities for environmental and atmospheric programs. He is currently project manager for the NASA Global Tropospheric Experiment and, in addition, serves as the assistant chief of the Atmospheric Sciences Division.*

Robert C. Harriss is *a graduate of Rice University where his graduate studies in geochemistry, marine science, and geology led to an M.A. in 1963 and a Ph.D. in 1965. He joined the NASA Langley Research Center in July 1978 following a teaching and research career at Florida State University, the National Science Foundation, and McMaster University. He is the project scientist for the NASA Global Tropospheric Experiment and, in additinn, conducts research on biogeochemical cycles of trace gases in the troposphere.*

James M. Hoell, Jr., *received a B.S. in physics from North Carolina State University in 1963 and a M.S. in physics from the College of William and Mary in 1967. Since joining the NASA Langley Research Center in 1963, his research has included the development of analytical techniques and radiance models to study remote sensing methods for measuring atmospheric properties and the development of instruments for measuring atmospheric species. He is the instrument scientist for the NASA Global Tropospheric Experiment and, in addition, conducts research on the chemistry of ammonia and other nitrogen compounds in the troposphere.*

News

Molecular-Orbital Experiments

Molecular orbitals (MO) are theoretical entities created to describe probability functions of bonding electrons in molecular groups. Whereas one-electron wave functions that describe atmic orbitals have been measured for decades by spectrographic techniques, bonding electrons in molecules have been less discrete objects to measure directly. The ultimate hopes of those engaged in applied MO theory in the field of mineral physics rile on being able to deduce the nature of bonding electrons precisely.

A new application of the so-called Penning ionization principle may make these hopes realizable; it offers the first opportunity to obtain by direct measurement quantitative electron densities within the outer orbitals. Called a Penning ionization electron spectroscopy (PIES) technique, this potentially major breakthrough in molecular orbital studies was developed by Koichi Ohno, Hideki Mutoh, and Yoshiya Harada of the University of Tokyo. As described recently, the results of the University of Tokyo group have shown that ". . . a spectroscopic technique can provide information about individual molecular orbitals and that . . . [the technique] . . . is most sensitive to the outer most orbitals" (*Chemical and Engineering News*, August 1, 1983).

Ohno et al. experimented with simple, molecular romponds such as water, nitrogen, carbon monoxide, and a few others. The spectroscopic rechnique analyzes electrons that are ejected from a sample material dur to an ionization process caused by the bombardment of a hearn of excited helium (metastable) atoms. In the spectrometer, the helium atoms collide with the sample and in su doing accept an electron transferred from the molecular outer orbitals. The molecule becomes ionized and the helium atoms allected return to the ground state. Electron transfer occurs with high probability just as the helium and molecule are separated by their van der Waals radii, and thus a momentary charge transfer orcurs at the puint of electron orbital overlap. The electrons are transferred to the inner-shell orbitals of the excited helium atoms from the outer orbitals of the molecules of the sample.

Because orbital overlap must occur to cause this process, the inner orbitals of the sample molecules are not detected with high probability or not at all. Orbitals that extend beyond the molecular surface have the highest probability of affecting electron transfer. In water molecules, for example, the outermost orbitals are detected with the greatest intensity. A PIES spectrum of water is a plut of energy versus electron density, each peak representing a separate outer urbital.

The origins of this application of the PIES technique can be found in recent developments of photoelectrum spectroscopy, in which it has been pnsible to relate molecular orbitals to ionizatinn bands in closed-shell molecules. Ionization potentials cnmpare inceptably with theoretical orbital energy values in certain materials. In the PIES technique, analysis of the kinetic energy (KE) distribution of the ejected electrons is made. The KE bands (equal to 0.5 MV^2 of the ejected electrons) are similar to those in an ultraviolet photo-electron spectrum of a sample material. These energies can in turn be related to the ionization potentials and thus to the absolute values of the orbital energies.

In their description of the technique, Ohno et al. state: ". . . phenomena which directly reflect orbital functions for 'individual' molecular orbitals have eluded observation hitherto, although 'total' electron densities have been measured by diffraction methods. . . ." This new method may prove to have exciting consequences in evaluating MO calculations that have been formulated for mineral structures.—*PMB*

New Consortium on Atmosphere

In July 1983 a group of universities and university-allied institutions established a new, not-for-profit consortium on atmospheric resources development.

The initial thrust of the Consortium will be to accomplish in-depth assessments of the scientific status and research needs in three key areas of atmospheric modification. These have been established as research relating to orographic precipitation enhancement with a major focus on application, delivery, and transport of seeding materials; basic research and hypothesis development relating to convective precipitation; and basic, applied, and societal research relating to radiation management. Scientific/technical committees composed of national experts including members of the Consortium and scientists from other institutions are being established. It is envisioned that available funding will be used to bring these three scientific committees together to perform major assessments of the scientific problems and the research needs as a prelude to development of future research plans to address various scientific questions identified in these three areas of research.

The Consortium is seen as a means for establishing the scientific basis for a more focused and better organized research.

Membership in the consortium is available to universities and university-allied research organizations who demonstrate an interest in an organization that will provide a broad base for involvement in basic, applied and societal research relating to atmospheric resources enhancement. There are 10 charter members of the consortium, although additional universities and allied research organizations may be admitted to membership upon the vote of two thirds of the board of directors. The charter members are: Brigham Young University, Colorado State University, Illinois State Water Survey, University of Missouri at Rolla, Montana State University, New Mexico State University, North Dakota University, South Dakota School of Mines and Technology, University of Utah, and Utah State University.

The consortium expects to work closely with University Corporations for Atmospheric Research and other similar groups to maintain close communication. The mailing address of the consortium is: Consortium for Atmospheric Resources Development, Atmospheric Sciences Department, Colorado State University, Fort Collins, CO 80523. The 1983 Annual Meeting of the Consortium will be held in November 1983 in Denver.

This news item was contributed by Stanley A. Changnon, Jr., *of the Illinois State Water Survey, Champaign, Il. 61820–0050.*

More Quakes, Fewer Deaths

During the first half of 1983 there were more significant earthquakes but fewer resulting deaths worldwide than during the same period last year, according to the U.S. Geological Survey. The number of significant earthquakes increased to 31 from 29 for the same period in 1982, while deaths decreased to 154 from 167. Only one significant earthquake and no deaths were reported in the United States this year. Significant earthquakes are defined as shocks that register at 6.5 or more on the Richter scale or those that register lower yet still cause casualties or considerable damage.

One of the strongest quakes recorded in 1983, registering 7.8 on the Richter Scale, occurred May 26 in the Sea of Japan off the west coast of the Japanese island of Honshu. The quake and the resulting tsunami, or seismic sea wave, were responsible for the deaths of 104 persons. In another major catastrophe, 30 persons were killed in a 5.9-magnitude quake that struck northern Iran on March 25.

During this period another major quake, recorded at 7.8, was centered in the sparsely-populated New Ireland region of the South Pacific, near the Solomon Islands; no deaths were reported.

On May 2 a quake registering 6.2 rocked Coalinga, Calif., injuring 45 persons, 18 seriously, and severely damaging the downtown area and more than 300 houses. Numerous aftershocks, some with magnitudes as great as 6.0, have been recorded in the area.

Of the 192 earthquakes recorded in the United States in the first half of 1983, 64 were felt in California, 61 in Alaska, 30 in Hawaii, 8 in Nevada, 4 in Montana, and 3 in Washington. Seventeen other states, reflecting a relatively even distribution across all regions of the country, also experienced tremors.

The earthquake statistics for 1982 (*Eos*, April 5, 1983, p. 129) and for the first half of 1983 reflect the continuation of an unusual, short-term pattern in seismic activity. Not only is the number of quake-related deaths far below the long-term average of 10,000 per year, but also a mere 5 quakes during the first 6 months of this year were 7.0 or greater, and none were recorded at 8.0. The long-term average is 18 earthquakes per year of 7.0 to 7.9 magnitude and one per year registering at least 8.0.

Geophysics Job Market

According to data released by the College Placement Council for the report year ending July, 1983, the job market for graduates in geophysics, engineering, and science reflects the reality of economic recovery. The number of job offers was down sharply, but this did not reflect the number of positions filled. At the bachelor's level, for example, there were 33,004 offers this spring, compared with 51,280 a year ago. The number of acceptances was estimated to have been about the same.

The top salary offers went again this year to petroleum engineers with little or no increase. The average starting salary offer was $30,816 per year. For the other engineering and scientific fields, the starting salaries ranged from about $23,000 to $26,736, the latter being the annual average for chemical engineers. The number of offers to engineers decreased this year, but the proportion was still 50% of the total job offers to graduating college seniors.

An area of technical employment that continues to be strong includes graduates at the master's degree level. Those graduates holding a technical undergraduate degree and a Master's of Business Administration (MBA) had the highest starting salaries except for engineers. This group of MBA candidates had average salary offers above $30,250. This amount constituted an increase of 9.1% over last year.

Humanities graduates did relatively well this year over past years. The candidates with bachelor's degrees in the humanities had average starting offers of over $16,550 per year. The total number of offers in this area increased over last year.

Offers to women graduates were up this year. There were no significant differences in men's and women's starting salary offers for engineering groups. In other technical fields, women's starting salaries were slightly lower than men's, but the gap appears to be narrowing. In economics, for example, the average starting salary offer to women was $19,116 per year, compared with the men's average of $19,056. These figures are based on data supplied to the College Placement Council from 185 placement offices at the 160 participating colleges and universities.

The July report is based on the survey of data on offers reported between September 1, 1982 and June 10, 1983. During that period, students accepted offers earlier and more quickly than in years past, allowing employers to make fewer offers to fill available positions.—*PAH*

EOS

Transactions, American Geophysical Union

The Weekly Newspaper of Geophysics

For speedier treatment of contributions send three copies of the double-spaced manuscript to one of the editors named below and one copy to AGU.

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Cover. Iceberg at 52°02'N, 55°00'W off the coast of Labrador on June 27, 1983. Four icebergs have been tracked by radar and LORAN C for periods of 1 to 5 days from CSS *Dawson* while an acoustic doppler current profiler continuously measured the currents close to the iceberg. Winds were monitored with an anemometer on a bow mast and the underwater size and shape of the iceberg were determined by sonar measurements. Data will be used in the development of numerical models of iceberg drift under the influence of winds and currents. The iceberg shown had an estimated mass of 1,100,000 metric tonnes and was 38 m high, 83 m deep, 110 m-wide, and 119 m long. (Photo courtesy of Stuart D. Smith, Bedford Institute of Oceanography, Dartmouth, N.S.; B2Y 4A2 Canada.)

Fellowships Available

NRC Asssociates

The National Research Council (NRC) is seeking applications for senior and postdoctoral associates for positions available in 19 federal agencies or research institutions. In 1984 approximately 250 new, full-time associateships will be awarded on a competitive basis for research in chemistry, engineering, and mathematics and earth, environmental, physical, space, and life sciences. Most of the programs are open to both U.S. and non-U.S. nationals and in recent Ph.D. recipients as well as to senior investigators. The deadline for applications is January 15, 1984.

The agencies and research institutions participating in this program provide the associates with opportunities to perform research on problems largely of their own choosing, yet compatible with the research interests of the supporting laboratory. The host institution provides the associate with facilities, support services, equipment, and travel funds necessary to conduct the research. The program also provides for relocation costs and for limited professional travel.

Awards are usually made for 1 or 2 years. Stipends for the 1984 program range from $24,000 a year for scientists receiving their degrees recently to approximately $50,000 for senior associates.

For more information about the fellowships contact Associateship Programs, Office of Scientific and Engineering Personnel, JH 608-D3, National Research Council, 2101 Constitution Ave., N.W., Washington, DC 20418 (telephone: 202-334-2760).

NSF Fellowships

Applications are available for National Science Foundation (NSF) Graduate Fellowships and Minority Graduate Fellowships for 1984–1985. The National Research Council will advise NSF in the selection of candidates for the fellowships. Awards will be made next spring.

Competition for these fellowships is open to U.S. nationals. Awards will be made on the basis of merit for full-time graduate study in physical, mathematical, biological, engineering, and social sciences, and in the history and philosophy of science. The fellowships are awarded for full-dme study leading to a master's or dnctoral science degree at any nonprofit U.S. or non-U.S. institution offering advanced degrees. These fellowships are renewable for up to 3 years subject to satisfactory academic progress and the availability of NSF funds. Application is limited to individuals with no more than 20 semester or 30 quarter hours credit of postbaccalaureate study in the science and engineering fields listed above.

NSF Minority Graduate Fellowships are available to U.S. nationals who are members of an ethnic minority group underrepresented in the advanced levels of U.S. science and engineering. Such minorities include American Indian, Black, Hispanic, Native Alaskan (Eskimo or Aleut), and Native Pacific Islander (Polynesian or Micronesian.

Both fellowship programs provide an annual stipend of $8,100. The application deadline for the NSF Graduate Fellowships and the NSF Minority Graduate Fellowship is November 23, 1983. Applicants are required to take the Graduate Record Examination.

For application materials and additional information, contact the Fellowship Office of the National Research Council, 2101 Constitution Avenue, Washington, DC 20418 (telephone: 202-334-2872).

Correction

An accotm of observations from the Scandinavian Twin Auroral Radar Experiment in the June 28, 1983, *Eos* ("STARE System Looks at ULF Magnetics," p. 428), inadvertently omitted a reference to the source of the observations, which was E. M. Poulter and E. Nielsen, "The Hydromagnetic Oscillation of Individual Shells of the Geomagnetic Field," *Journal of Geophysical Research*, 87, 10,432–10,438, 1982.

Eos To List Ph.D. Data

Eos plans to list, regularly, the titles and authors of recently accepted doctoral dissertations in the disciplines of geophysics. The listings will begin with degrees awarded since January 1, 1983.

Faculty members are invited to submit information concerning recently accepted Ph.D. dissertations on stationery of the degree-granting institution above the signature of the faculty advisor or department chairman. The information must include the following four points, which will be published as received:

(1) Title of the dissertation. (If work is not written in English, give the English version of the title, and the name of the original language)
(2) Author
(3) Name of department and institution granting the degree
(4) Month and year degree was awarded

If possible, include the address and telephone number of the degree recipient and infnrmation on how a copy of the dissertation or its abstract may be obtained.

Send the information to *Eos*, 2000 Florida Avenue, N.W., Washington, DC 20009.

Books

Advances in Irrigation

Vol. 1, D. Hillel (Ed.), Academic, New York, xvii + 302 pp., 1982, $37.50.

Reviewed by W. R. Gardner

This is the first volume of *Advances in Irrigation*, a new serial publicatinn by the publishers of *Advances in Agronomy* and *Advances in Hydroscience* and designed to follow the same format. The editor is a well-known researcher and writer on irrigation and related subjects and has assembled a collection of highly regarded and respected authors for the initial volume. The readership for this volume will probably be mainly specialists and students interested in irrigation and an occasional design engineer.

The seven contributions in this volume fall roughly into two classes: research and practice. Three papers ("Conjunctive Use of Rainfall and Irrigation in Semi-arid Regions," by Stewart and Musil, "Irrigation Scheduling Using Soil Moisture Measurements: Theory and Practice," by G. S. and M. D. Campbell, and "Use of Solute Transport Models to Estimate Salt Balance Below Irrigated Cropland," by Jury) cover topics that have been the subject of a number of reviews. The contributions here provide brief, well-written, and authoritative summaries of the chosen topics and serve as good introductions or reviews. They should lend themselves well to classroom use in various ways. They also should be helpful to the nonspecialist interested in getting a sense of the subject without going into great detail.

The paper by Stewart and Musik treats a subject that deserves much more attention. Conjunctive use of rainfall and irrigation is a rapidly increasing practice and poses challenging research and design problems that have been inadequately explored in the field. To an irrigator in the arid west, it seems anomalous to hear about drought in a region with a water table less than 30 m below the root zone. Stewart and Musik present an imaginative way to adapt irrigation to an unpredictable precipitation, and the thoughful reader should be intrigued by the potential management schemes that might be devised for regions with appreciable, but still inadequate, precipitation. It is unfortunate, but true, that the concepts described in these three papers play little role in the practice of irrigation. Despite 100 years of irrigation research, irrigatim practice in the arid portions of the United Sates is still largely a marter of trial and error. Only a few progressive farmers or irrigation districts practice irrigation scheduling according to any rule other than the calendar, and irrigation system design as it is now practiced is decades behind the state of the art. If farmers were as reluctant to try new crop varieties or new insecticides as they are to adopt new irrigation practices, hybrid corn would still be an experimental novelty.

The other four papers in this volume come closer in tone and substance to actual practice. The chapter by R. D. Jackson on "Canopy Temperature and Crop Water Stress" gives the scientific basis for the use of temperature sensing to evaluate and schedule irrigation. While this technique is not now used even experimentally, the nature of the equipment and the procedures suggest that in those arid regions where the concept is valid, it may lend itself to adoption well before methods with a much longer history. The reader unfamiliar with this approach and seeking a good introduction to the subject is well served by the review. While many aspects of the topic are still hotly debated by the experts, it is a very promising approach and deserves wider experimentation.

"Level-Basin Irrigation," by A. R. Dedrick, L. J. Erie, and A. J. Clemmens, provides procedures for the design and evaluation of this technique, which should be very useful to the design engineer and which should help the extension soil scientist or irrigation engineer in advising farmers about the wisdom and merits of leveling. In recent years, laser leveling of fields has been expanding widely in Arizona and adjoining states with very favorable results in almost all cases. The economic benefits of this practice are already deemed to exceed the costs, and unlike irrigation scheduling, it is solidly entrenched in practice. A good criterion for the acceptance of a practice by the agricultural community is the familiarity and understanding of it held by the agricultural bankers who finance the practices.

"Flow Measurement Flumes: Applications to Irrigation Water Management," by J. A. Replogle and M. G. Bos, deals with an extremely important subject. Poor management of irrigation water starts with inadequate information about how much water is being applied. There are numerous mechanical devices on the market for use in water measurement. The State of Arizona has mandated that irrigation wells use such a device and that groundwater pumpage be reported annually to the state. The flumes, largely designed by Replogle and coworkers, offer a cost effective way to achieve water measurement with surprising precision. The necessary tables and charts for design and calibration are found here and anyone interested in flow measurement in open channels would be well advised to become familiar with this chapter.

The final chapter, by D. S. Bucks, F. S. Nakayama, and A. W. Warrick on "Principles, Practices, and Potentialities of Trickle (Drip) Irrigation," is a summary of over a decade of research on a topic that is receiving rapidly increasing interest in water-short states. The installation of 10,000 acres (4,000 hectares) of drip system on one cotton farm near Gila Bend, Ariz., this spring represents a strong vote of confidence in the future of this practice by at least one investor. While the future of drip irrigation appears much more assured than it did 10 years ago, there is still much to research. Emitter design has improved considerably, clogging problems are more nearly under control, and many agronomic management problems are better understood. However, much remains to be done. System design has far outstripped practice, management of the tapes (whether buried or on the surface) is still problematic, and how best to supply fertilizers, herbicides, and other chemicals is still very much subject to trial and error. The large number of separate topics dealt with in this paper should give the reader at least a modest idea of the unfur management and design problems that accompany such a drastic change in the way water is delivered to the root zone. A total systems approach is required, including consideration of labor management, insect and weed management, as well as water and fertility management. Revolutionary does not seem too strong a word to describe the change.

In summary, the editor has collected a worthwhile set of papers. Whether this quality can be maintained in future volumes remains to be seen since one can easily skim off the cream in a first volume. My main reaction to this volume is one of despair at the very widening gulf between theory and practice in irrigation. The editor of this volume has achieved his stated goals, but if he can find a way to convey the message to the actual practitioners of irrigation, he will have made a much more significant accomplishment.

W. R. Gardner is with the Department of Soils, Water, and Engineering, College of Agriculture, University of Arizona, Tucson, AZ 85721.

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For further information, call toll free 800-424-2488 or, in the Washington, D. C., area, 462-6903.

POSITIONS AVAILABLE

The University of Missouri-Columbia/Faculty Positions. The University of Missouri-Columbia Department of Geology plans immediate expansion through the addition of three tenure-track faculty positions. Appointments are anticipated at the assistant professor level, although higher ranks may be possible, beginning in August of 1984. Candidates will be expected to have completed requirements for the Ph.D. degree by that time. Faculty members are required to provide quality instruction at both undergraduate and graduate level, and conduct research leading to scholarly publications. Successful candidates will be chosen from the following specialties:

Exploration Geophysics
Solid-Earth Geophysics
Hydrogeology
Analytical Structural Geology
Clastic Sedimentology

Applications should send resume, transcripts, and names and addresses of three references to:

Tom Freeman, Chairman
Department of Geology
University of Missouri
Columbia, MO 65211

Tenure-Track Faculty Position-Geophysics/New Mexico State University. We are seeking a faculty member whose duties will include teaching both undergraduate and graduate level courses, coordinating research and supervising graduate level thesis and dissertation research. We are particularly interested in a seismologist, but persons with experience in other geophysical techniques are invited to apply.

Minimum qualifications include an earned doctorate in geophysics or a closely related area and demonstrated research capability. Teaching experience and demonstrated ability to secure research funding are desirable. The position is available in January 1984 for 9-month academic year. Appointment will be at the rank of Assistant or Associate Professor. Salary and academic rank will be dependent on experience and qualifications.

Applications and names, addresses and telephone numbers of at least three references should be submitted to Dr. Chandler Swanberg, Department of Earth Sciences, P.O. Box 3AD, Las Cruces, NM 88003.

Applications received by October 15, 1983 will be given preference.

New Mexico State University is an Affirmative Action/Equal Opportunity Employer.

Chairman-Department of Geological Sciences/Wright State University. The Department of Geological Sciences invites applications for the position of chairman to be appointed September 1984. We seek a dynamic individual with administrative talent and an appreciation for research and practice-related educational activities. Rank is at the full professor level and no restrictions have been placed on areas of specialization. The department is active with 12 faculty and an emphasis on professional practice, yet maintaining a firm commitment to basic research.

Send a letter of application, curriculum vitae and names of three references to:

Chairman, Search Committee
Department of Geological Sciences
Wright State University
Dayton, OH 45435

Wright State University is an affirmative action/equal opportunity employer. Closing date for the position is October 31, 1983.

Earth Sciences

The Lamont-Doherty Geological Observatory of Columbia University invites scientists interested in any field of the earth sciences to apply for the following fellowships: Two postdoctoral fellowships, each awarded for a period of one year (extendable to two years in special instances) beginning in September, 1984 with a stipend of $25,000 per annum.

Completed applications are to be returned by January 15, 1984. Application forms may be obtained by writing to the Director, Lamont-Doherty Geological Observatory, Palisades, New York 10964. Award announcements will be made February 28, 1984, or shortly thereafter.

Columbia University is an Affirmative Action/Equal Opportunity Employer.

Department of Geology/Southern Illinois University at Carbondale. Applications are invited for a tenure track position at the Assistant or Associate Professor Level starting in August, 1984.

Candidates must have the Ph.D. degree or expect completion by Fall 1984. Rank and salary are open depending upon qualifications and experience. We seek a candidate whose research and teaching interests are in the field of seismology. Persons with specific interests or experience in applied seismology, petroleum exploration or ore deposits are encouraged to apply. Duties will include undergraduate and graduate teaching supervision of theses, and development of a research program in the area of specialization.

Application deadline is December 2, 1983. Send letters to Lawrence L. Mollicoujice, Department of Geology, Southern Illinois University, Carbondale, IL 62901. Southern Illinois University at Carbondale is an equal opportunity employer.

Monash University—Department of Earth Sciences Continuing Leadership in Geophysics. Geophysicist to initiate a geophysics program in January 1984 to complement an already comprehensive geology program. A second appointment is planned for 1985. Applicants must have experience in geophysical data collection, field programs and data interpretation in exploration. Interest in electromagnetics desirable. The appointee will plan a geophysics curriculum, teach undergraduate courses and help develop a graduate program to Ph.D. level. Salary: $A22,436—$A29,407. Applications including Ref. no. 41812, curriculum vitae and 3 referees to the Registrar, Monash University, Clayton, Vic. 3168, Australia by October 24, 1983.

Meteorologist/The City College of The City University of New York. The Department of Earth and Planetary Sciences invites applications for an anticipated opening in meteorology. The appointment will start September, 1984. Applicants should have completed the Ph.D. by the time of appointment and have a strong background in synoptic meteorology and computer applications. In addition, the individual should have an interest in atmospheric chemistry or pollution as applied to urban areas, or physical oceanography. The person hired will be required to teach courses in meteorology, and possibly physical oceanography as well as develop and maintain an active research program. Participation in the C.U.N.Y. Ph.D. Program in Earth and Environmental Sciences is anticipated. Rank and salary will be commensurate with experience. Send resume, transcripts and three letters of reference by November 30, 1983 to Professor Dennis Weiss, Chairman, Department of Earth and Planetary Sciences, The City College, 138 Street and Convent Avenue, New York, N.Y. 10031.

The City College of the City University of New York is an equal opportunity affirmative action employer.

Rensselaer Polytechnic Institute/A Tenure-Track Faculty Position and a Post-Doctoral Research Position. The Department of Geology of Rensselaer Polytechnic Institute is seeking applicants for two openings, a tenure-track faculty position and a post-doctoral research position.

The faculty position available in September 1984 requires a Ph.D. or equivalent degree. The area of specialization within the geosciences is open. Particularly important is the applicant's interest in research and teaching at both the undergraduate and graduate levels (M.S. and Ph.D.) with capability to do creative research in the quantitative sciences. Preference will be given to individuals with research experience beyond the Ph.D.; the level of the appointment is open.

The postdoctoral position is available beginning January 1984 to do research in the field of fission track analysis applied to studies of sedimentary basins. Applicants must be knowledgeable and experienced in fission track analysis.

Our present department is part of a modern, technologically-oriented university, and consists of seven members whose collective expertise encompasses structural geology, geophysics, geochemistry, petrology, glacial and artificial geology, and ecological modeling. The RPI environment provides ample opportunities for field and laboratory experimental research in geology, as well as for interdisciplinary studies in chemistry, physics, biology, mathematics, materials science, engineering and computer science.

A resume and the names of three persons who would be willing to provide letters of reference should be sent to: Donald S. Miller, Chairman, Department of Geology, Rensselaer Polytechnic Institute, Troy, NY 12181.

Rensselaer is an Equal Opportunity/Affirmative Action Employer.

University of Minnesota Stratigrapher/Sedimentary Petrologist. Tenure-track position starting Fall 1984, probably at the Assistant Professor level. The candidate must have a Ph.D. with interest in stratigraphy of sedimentary basins, tectonics and sedimentation, and sedimentary petrology, and will be expected to carry out research and to teach graduate and undergraduate courses in these fields. Please submit resume, academic records, and three letters of recommendation to Dr. Peter J. Hudleston, Department of Geology and Geophysics, 108 Pillsbury Hall, University of Minnesota, Minneapolis, MN 55455 (612)373-3373.

The University is an Equal Opportunity/Affirmative Action Employer.

University of Cambridge, Gullard Labs./Seismologist. Postdoctoral research position available in the Marine Geophysics Group. We have an active program involving two-ship multichannel seismic experiments on the U.K. continental margin, construction of digital OBS, seismic refraction experiments on the continental shelf, the deep oceans, passive and active margins and aseismic ridges, and the development and application of new interpretation methods, with opportunities to initiate new projects. Initially funded for 2 1/4 years.

Send resume and names of two referees or requests for further details to Dr. R.S. White, Bullard Laboratories, Madingley Road, Cambridge, U.K.

An equal opportunity employer.

Geochemistry/University of Illinois at Urbana-Champaign. The Department of Geology invites applicans for a tenure-track faculty position in geochemistry. We are seeking candidates who have clearly demonstrated the potential to be outstanding researchers in the general area of low-temperature geochemistry and whose future research efforts will complement our existing programs in the petrology and diagenesis of sediments, stable isotope studies, and fluid-rock interactions. In addition to the development of a strong research program, the successful candidate is expected to participate in all aspects of teaching and advising at the graduate and undergraduate levels.

The Department of Geology houses a variety of facilities for geochemical research including an atomic absorption spectrophotometer, x-ray diffraction and fluorescence units, an isotope-ratio mass spectrometer, and two electron microprobes. Numerous other analytical facilities are available on campus.

This position is available immediately. We expect to make the appointment at the Assistant Professor level. Salary will be commensurate with experience and qualifications. For equal consideration, please submit a letter of application which includes a statement of current and future research interests as well as curriculum vitae, bibliography, and the names of 3 references willing to comment on your qualifications and promise to Thomas F. Anderson, Department of Geology, 245 Natural History Building, 1301 W. Green St., Urbana, IL 61801, (217)333-0585 by November 30, 1983. The University of Illinois is an equal opportunity/affirmative-action employer.

POST-DOCTORAL INVESTIGATOR

Woods Hole Oceanographic Institution invites applications for the position of Post-Doctoral Investigator. This position is being offered for basic research on the organic geochemistry of sediment and sea water particulate matter from hydrothermal vent systems. The importance of the microbiological community in determining the organic chemical composition of particulate material will also be investigated. Preference will be given to applicants with training in organic chemistry, organic geochemistry, trace organic chemical analysis, chemical/microbiological interactions, or mass spectrometry. Send resume and name of 3 referees to:

Personnel Manager
Box 54P

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THIS IS A TEMPORARY FULL-TIME POSITION FOR 1 YEAR WITH THE OPPORTUNITY FOR A SECOND YEAR APPOINTMENT

An equal opportunity employer M/F/H

Professor of Marine Geophysics Terman/Stanford University. The Department of Geophysics, Stanford University, is seeking candidates for a tenure track position in the broad area of marine geophysics and tectonics. We seek a creative scientist with experience in gathering, interpreting, and modeling marine geophysical data and whose research interests cover the positional, igneous, and seismic processes on oceanic ridges and continental margins. Inquiries are invited from marine geophysicists with demonstrated scientific record in one of the above aspects of marine geophysics or tectonics, who have demonstrated an ability to develop new ideas and research directions, and to guide graduate and undergraduate students. Individuals considering this appointment we are interested in maintaining interactions with ongoing research groups in marine geology, plate tectonics, paleomagnetism, seismology and regional geology at Stanford. Our new faculty member will be expected to develop a strong research program involving both government and industrial participation.

Salary and rank will be commensurate with experience and background. Please submit a resume, a brief description of teaching and research interests and references to:

Dr. Amos Nur
Department of Geophysics
321 Mitchell Building
Stanford University
Stanford, CA 94305

Stanford University is an equal opportunity employer, and encourages the application of qualified women and minorities.

DIRECTOR WATER RESOURCES RESEARCH CENTER UNIVERSITY OF ARIZONA

Applications are invited for the position of Director of the Arizona Water Resources Research Center. The Center, located at the University of Arizona, is an interdisciplinary organization formed in response to the 1964 U.S. Water Resources Act and is devoted to assisting water-related research activities at the three state universities and to the dissemination of results of water-related research in the State. It also conducts research investigations within its organization, with special emphasis on the urban, industrial and agricultural water use issues of arid and semi-arid regions. Candidates should possess an earned Ph.D., preferably in engineering or a natural science, an established research and administrative record, and familiarity with the role and operations of a state water resources research center. Please send an application, curriculum vitae, and the names of three references to:

Dean, College of Engineering
Bldg. 72
University of Arizona
Tucson, AZ 85721

Closing date is December 1, 1983. UA is an equal opportunity employer.

RESEARCH ECONOMIC GEOLOGIST

The Department of Mineral Sciences at The American Museum of Natural History is seeking applicants for a curatorial research position in Economic Geology. Major responsibility is to carry out a vigorous research program involving field and laboratory studies on the origin and development of ore deposits anywhere in the world. Close working relationships with other researchers to broaden the scope of the work are encouraged. Involvement with graduate students, if desired, is also possible. Minor responsibilities include some collections development and public programs (symposium or exhibition). The position offers the freedom and support to carry out major research projects on a large scale, unfettered by major administrative or academic responsibilities.

The Department has excellent laboratory facilities including an automated electron microprobe, X-ray facilities, sample preparation laboratory, photographic and graphic support, and computers. A PhD in Economic Geology is required and the position is open to persons of any rank, with salary negotiable.

Candidates should submit a resume (including a statement of research interest), salary requirements, and the names of three references by October 15, 1983 to:

Dr. Martin Prinz, Search Committee
THE AMERICAN MUSEUM OF NATURAL HISTORY
79th Street at Central Park West, New York, N.Y. 10024

An equal opportunity (M/F/H) affirmative action employer.

Project Manager—**Materials Sciences (Columbus, Ohio location).** The Project Management Division of Battelle Memorial Institute has an immediate opening in its Office of Nuclear Waste Isolation (ONWI) for a person to assist in all aspects of management of subcontracts in materials science; review technical quality of the work and coordinate programmatic application of the results; develop data base and models from results of subcontractors; perform design analyses of materials behavior, waste form behavior, and near-field interactions for waste packages, repository seals, and other repository items.

Requirements include superior written and oral communications skills, and an M.S./Ph.D. in materials science specialty. Demonstrated leadership qualities and experience in nuclear waste disposal and management of large projects/R&D efforts desirable.

We offer a comprehensive benefits package and an excellent salary, commensurate with your background. Send your resume, in confidence, to Personnel Office, Battelle Project Management Division, 505 King Avenue, Columbus, Ohio 43201.

An Equal Opportunity Employer.

Postdoctoral Research Associate Position/Johns Hopkins University. Positions are available for studies of planetary magnetospheres, and for analysis of earth magnetospheric and auroral physics, as well as in a newly initiated program in solar physics. Selected candidates will participate in the analysis and interpretation of data obtained from deep space probes (Voyager), or particle field, and solar or atmospheric emissions data from earth orbiting spacecraft. Positions are one year, renewable appointments with flexible starting dates. Contact: Ned Mall, Department LFR-320E The Johns Hopkins University Applied Physics Laboratory, Johns Hopkins Road, Laurel, Maryland 20707.

An Equal Opportunity Employer M/F.

Iowa State University of Science and Technology, Department of Earth Sciences. Applications are invited for a tenure track faculty position in Meteorology. Rank is at the assistant or associate professor level dependent upon qualifications. The successful applicant will be expected to develop a strong research and graduate student program and will teach undergraduate and graduate courses for meteorology majors.

The position is for a person with proven expertise within the general area of dynamic meteorology. Teaching will involve an undergraduate course in synoptic meteorology, in addition to courses related to the field of expertise. Completion of the Ph.D. prior to appointment is strongly preferred. In addition, research ability shown by other publications and/or postdoctoral experience will be an advantage.

Iowa State offers degrees in meteorology through the Ph.D. The program includes about 60 undergraduate majors; the graduate/research program is strong and emphasizes theoretical, dynamic studies. Close relationships are established with the facilities and personnel of major national laboratories. New campus facilities for meteorology are currently under construction.

The appointment is expected to begin no later than September, 1984; an appointment starting the current academic year may be possible. Application deadline is November 1, 1983; later applications will be accepted if the position is not filled. For application information please write to:

Dr. Bert E. Nordlie
Department of Earth Sciences
Iowa State University
253 Science I
Ames, Iowa 50011.

Iowa State University is an equal opportunity/affirmative action employer.

Research Agricultural Engineer/Tillage Research. Qualified candidates are invited to submit applications for a two year research position in the Department of Agricultural Engineering at Texas A&M University. The research deals with the examination of soil mechanical processes and water energy losses in agricultural tillage systems. Desirably candidates should have at least an M.S. degree but preferably a Ph.D. in agricultural engineering or closely related field. Submit resumes and names and addresses of three references to Dr. E. A. Hiler, Head, Department of Agricultural Engineering, Texas A&M University, College Station, TX 77843. Telephone: 409-845-3931.

Texas A&M University is an equal opportunity/affirmative action employer.

University of Florida. The Department of Geology invites applications for a tenure-track position beginning with the fall term, 1984. The position will be filled at the assistant or associate professor level. A Ph.D. is required and salary will be commensurate with qualifications. Although any research specialty will be considered, preference will be given to those with interest in these general areas: geochronology-isotope geology or low-temperature geochemistry-chemical sedimentology. Send curriculum vitae and 3 letters of reference by January 15, 1984 to: Dr. N.D. Opdyke; Department of Geology; 114 CGA; University of Florida; Gainesville, Florida 32611.

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Geophysicist. Applications are invited for an anticipated tenure track position in geophysics August 1984 (possibly Jan. 1984). Preference given to candidates with experience in exploration geophysics. Ph.D. required. Contact Lloyd Schmaltz, Department of Geology, Western Michigan University, Kalamazoo, Michigan 49008 (616-383-1778).

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Department of Geosciences/University of Houston. The Department of Geosciences is interested in having applications for tenure track positions in the following areas: (1) Geophysics—seismology, exploration, data processing (2) Petrology—sandstones and metamorphic (3) Geochemistry—diagenesis. Salary and rank commensurate with experience. If interested, please send:

(1) A curriculum vitae
(2) A brief statement of teaching and research interests
(3) Three letters of recommendation to:

Dr. John C. Butler
Department of Geosciences
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AGU

Bacon-Bercey Award to Lundberg

Laura L. Lundberg, a first-year graduate student in chemistry at the University of California, San Diego, is the recipient of the 1983 June Bacon-Bercey Scholarship for Women in Atmospheric Sciences. The scholarship, administered by AGU, is provided through a gift from June Bacon-Bercey, a noted meteorologist.

Lundberg's association with atmospheric sciences is recent. She received a B.A. in chemistry in May 1982 from Douglass College, Rutgers University, where she worked with G. F. Herzog in studying beryllium-10 in sediment and soil samples from the Maurice River-Union Lake system in New Jersey. That research generated an article in the May 20, 1983, issue of the *Journal of Geophysical Research* (vol. 88, Lundberg et al., pp. 4498–4504).

When she entered the Ph.D. program at the University of California, Lundberg's intention was to specialize in cosmochemistry; she has since worked on an atmospheric chemistry project of M. Thiemens and J. Heidenreich that has implications for cosmochemistry. The research involves finding a method for collecting atmospheric ozone to measure its isotopic ratios. The project may yield a new tracer for stratospheric and tropospheric mixing.

While many chemists look to private industry for career opportunities, Lundberg's goals are somewhat different. "My specific goals after earning a Ph.D. are to continue research first as a post-doctoral fellow in order to broaden my analytical experience and knowledge . . . and then ultimately to pursue an academic career."

Lundberg is the sixth recipient of the Bacon-Bercey Scholarship. Offered to first-year graduate students, to undergraduates who have been accepted to graduate programs, and to students beginning a B.A. program after receiving an A.A., the $5001 award is given to a woman who is starting out on a promising career in the atmospheric sciences. AGU's Education and Human Resources Committee, in consultation with the Atmospheric Sciences Section, selects the winner.

AGU is again offering the scholarship for the 1984-1985 school year. For application forms and for details about eligibility requirements, write or call AGU Member Programs Division, 2000 Florida Avenue, N.W., Washington, DC 20009 (telephone: 202-462-6903). The deadline for applications is May 1.

1984.—*BD*

AGU (cont. on p. 5760)

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FAS

AGU *(cont. from p. 565)*

Membership Applications Received

Applications for membership have been received from the following individuals. The letter after the name denotes the proposed primary section affiliation.

Mohamed Abdulrazzak (H), Larry Allen (S), J. Kaspar Arbenz (T), Brian C. Beckman (G), Barbara V. Braatz (O), Jean A. Calhoun (T), James Carton (O), John Robert Conolly (V), Michael P. Convery (H), Arthur Croucher (S), James Derek Fairhead (T), J. G. Fitton (V), Peter W. Francis (V), James K. Fulford (O), Keith E. Green (T), Nina Haas (T), Jong Hwan Han, Heinrich Hinze (G), Klaus Peter Koltermann (O), Andy Lane (S), Chih-Ping J. Lu (S), Paul Andrew Mayewski (A), Eileen McLellan (V), Andrew J. Miller (H), Francis M. Monaldo (O), Langley R. Muir (O), Forrest G. Neil (H), Yuko Oguchi (S), Alison Ord (T), Keith Peacock (O), Suparb Poobrasert (T), Richard N. Pugh (P), Antonio F. Quesada (SA), Oleg Raspopov (SM), Michael John Rickard (T), J. R. Rodriguez (H), Scott L. Sandall (A), Hans W. Schenke (G), Roman A. Schmitt (P), Guenther Schmenharting (T), Richard Schofield (V), Ramesh P. Singh (GP), Stephen Sleem (V), Jean E. Snider (O), Mindi B. Sneparsky (S), Dion C. Stewart (V), Michael L. Terstriep (H), Steve Y. Tsai (H), Paul J. Unhoefer (T), Hendrik M. Van Aken (O), Peter John Waite (A), Robert A. Wharton (O), Michael E. Zolensky (V).

Student Status

Timothy D. Bechtel (T), Robert Boiko (O), Ethan Brown (S), Christoph Clauser (T), Chris R. Dillistone (S), Sylvia A. Edgerton (A), Sandy Elder (H), Neil F. Humphrey (H), J. David Johnston (T), Steffen Konrad, Charles E. Larson (H), Albert Losher (V), Kyoung-Won Min (V), Larry Neubauer (A), Christian T. Rack (H), Volkhard Spiess (GP), W. J. Tangren (P), Anita L. Wouldridge (S), Horst-U. Worm (GP).

Lecturers for AGU Science and Policy Seminars Sought

AGU is establishing a series of Science and Policy Seminars. AGU members who have worked with public policy issues involving geophysics are invited to share with university students and faculty their experiences, insights, and expertise. For guidelines on this new and exciting program and application information, write or call:

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Meetings

Announcements

Polar Research

An Arctic and Antarctic research symposium will be held October 12–14, 1983, in Washington, D. C., under the sponsorship of the U.S. Geological Survey (USGS). Open to the public, with no registration required, the symposium will consist of more than 50 technical papers on USGS research in geology, geophysics, energy and mineral resources, cartography, physical sciences, and glaciology.

The program begins daily at 8:30 A.M. in the auditorium of the National Academy of Sciences (NAS), 2101 Constitution Avenue, N.W. There will be a reception and dinner on October 12, followed by the Antarctican Society Memorial Lecture, to be delivered by Tucker Scully of the U.S. Department of State on "The Future of the Antarctic Treaty System." Dinner reservations, at $20 per person payable to NAS, should be made by October 7 with the NAS Polar Research Board at the above address. Additional information is available from Thomas L. Holzer, USGS, 104 National Center, Reston, VA 22092, telephone 703-860-7480.

The complete Geophysical Year last appeared in the August 30, 1983, *Eos*.

Scholarship Assistance for Minority Students in Earth, Space, and Marine Science 1984—1985

The American Geophysical Union is once again pleased to participate in the American Geological Institute's Minority Scholarship Assistance Program. Approximately 70 awards from $500–$1500 are expected to be awarded for this term.

Eligible candidates are:

- Graduate or undergraduate students with good academic records;
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For a flyer for your student, call or write to:
Members Programs • American Geophysical Union • 2000 Florida Ave., N.W. • Washington, D.C. 20009 • (202) 462-6903

For applications, call or write:
Don Diego Gonzalez • Sandia Laboratories • P.O. Box 5800 • Organization 4731 • Albuquerque, NM 87115 (505) 844-8849

Application Deadline, February 1, 1984

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(L) ☐ LIFE MEMBERSHIP. A single payment (currently $300) is acceptable in lieu of annual dues. Privileges accorded are those granted to all members and have been changed from time to time.

PUBLICATIONS

MEMBER JOURNAL SUBSCRIPTION RATES — 1984

As an AGU member or associate, you will receive *Eos* each week. You may subscribe to additional publications at very low member rates; simply check those desired. Subscriptions are on a calendar year basis. New members will receive back issues of these journals to the beginning of the year. Remember to add payment to your member dues. Members outside the U.S. must add to the subscription rate the foreign postage surcharge. Additional charge for airmail of printed edition quoted on request. Service does not begin until payment is received. In accepting journals at these rates you are agreeing that the issues will not be used in libraries or reading rooms for at least two years.

Member or Associate	Student	*Foreign Postage Surcharge	Microfiche Edition (Airmail)	Printed Edition	(Select either microfiche or printed edition)
				☐	Eos ($14 of dues is allocated).
					Journal of Geophysical Research is published in three monthly sections.
$50	$25	$18	☐	☐	Space Physics, Section A (blue) Bengt Sonnerup, Editor; 4,200 pages anticipated for 1984.
$52	$28	$18	☐	☐	Solid Earth and Planets, Section B (red) Gerald Schubert, Editor; 4,300 pages anticipated for 1984.
$38	$18	$18	☐	☐	Oceans and Atmospheres, Section C (green) William L. Chameides, Editor, Atmospheric Chemistry and Aeronomy; James J. O'Brien, Editor, Oceanography and Boundary Layer Meteorology. Members may subscribe to the full section or to either half of JGR Green published in alternate months for half the subscription price. 3,200 pages anticipated for 1984.
$19	$8	$9	☐	☐	Atmospheric (only)
$19	$9	$9	☐	☐	Oceanography (only)
$47	$23	$8	☐	☐	Water Resources Research Published monthly. Recognized as the leading journal in the water sciences (containing both natural and social sciences). Stephen J. Burges and Ronald Cummings, Coeditors. 2,000 pages anticipated for 1984.
$16	$16	$4	☐	☐	Reviews of Geophysics and Space Physics An important addition to each geophysicist's permanent library; James Heirtzler, Editor. 800 pages anticipated for 1984.
$22	$22	$5	☐	☐	Geophysical Research Letters Reaches more members than any other AGU publication except EOS; monthly reports of fast moving areas of research. Rob Van der Voo and James C. Walker, Coeditors. 1,400 anticipated for 1984.
$30	$27	$6	☐	☐	Radio Science Published six times a year. K.C. Yeh, Editor. 1,100 pages anticipated for 1984.
$28	$12	$4	☐	☐	Tectonics Published bi-monthly. The newest addition to AGU's family of prestigious journals, Tectonics is devoted to publishing leading papers in the structure and evolution of the terrestrial lithosphere, integrative tectonics, structural geology and materials sciences. Editor, John F. Dewey. 640 pages anticipated for 1984.

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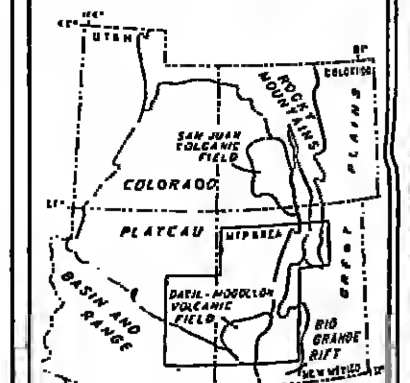

THE RIO GRANDE RIFT AND SOUTHEASTERN COLORADO PLATEAU, NEW MEXICO, AND ARIZONA—1983

by W. S. Baldridge, Y. Bartov, and A. Kron

This map indicates the geologic ... al relationships among the ... elements of the Rio Grande Rift ... Colorado Plateau and Basin and Range ... inces.

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Electromagnetics

6??? Scattering
SCATTERING OF ELECTROMAGNETIC WAVES FROM A HALF SPACE OF DENSELY DISTRIBUTED DIELECTRIC SCATTERERS
L. Tsang (Electrical Engineering Department, Texas A&M University, College Station, Texas 77843), J. A. Kong

The scattering of a plane wave obliquely incident on a half space of densely distributed spherical dielectric scatterers is studied. The quasi-crystalline approximation is applied to truncate the hierarchy of multiple scattering equations, and the Percus-Yevick and the Verlet-Weis results are used to represent the pair distribution function. The coherent reflected wave is studied with these approximations. The incoherent scattered wave is calculated with the distorted Born approximation. In the low-frequency limit, closed-form expressions are obtained for the effective propagation constants, the coherent reflected wave, and the bistatic scattering coefficients. Results at higher frequencies are calculated numerically. The advantage of the present approach is that in the low-frequency limit, it reproduces the effects of specular reflection, Fresnel reflection coefficient, Brewster angle, and Clausius-Mossotti relation. In addition the classical results, the bistatic scattering coefficients are also calculated. The theory is also applied to match backscattering data from dry snow at microwave frequencies (Scattering, dense medium)
Rad. Sci., Paper 3S1008

Exploration Geophysics

[illegible]

Hydrology

[illegible]

Mineralogy, Petrology, and Crystal Chemistry

[illegible]

sions are half those of the spinel unit cell. After the time of 3 to 4 spectrum acquisitions, all of the peaks of the spinel structure were present. This same effect was observed in two other series. An additional series was run at 400°C. As soon as the γ-phase peaks appeared, the run was halted and the sample was quenched and examined by the Debye-Scherrer method. The only γ-phase peaks observed were those also allowed for a structure with the smaller unit cell). These results are consistent with a restacking of the anions from the approximately hexagonal close packed (hcp) arrangement in the olivine structure to the nearly cubic close packed (ccp) arrangement in the spinel structure followed later by a reordering of the cations. (Olivine, phase changes, synchrotron radiation)
J. Geophys. Res., Red, Paper 3B1451

8270 Properties of Minerals (quartz)
SURFACE AND INTERFACIAL FREE ENERGIES OF QUARTZ
George A. Parks (Department of Applied Earth Sciences, Stanford University, Stanford, CA, 94305)

Water and electrolytes cause significant changes in brittle fracture strength and sub-critical fracture propagation velocities in quartz and quartz rocks. These changes may be caused, in part, by changes in surface free energy. Experimental fracture surface energies of quartz range from about 400 mJ/m² to about 11.5 mJ/m². Thermodynamic surface free energies are likely to be lower than fracture surface energies owing to dissipative energy losses. Thermodynamic surface energies are sensitive to environmental composition. Reaction of water vapor with pristine fracture surfaces reduces energy by hydroxylation, but the amount of reduction is not known. Adsorption of water vapor on the hydroxylated surface and immersion in liquid water reduce surface energy by 15 to 230 and 12 mJ/m² respectively. In an electrolyte, the surface energy is maximum at the point of zero charge, where adsorption of ionic solutes is least. Adsorption of hydrogen ion, hydroxide ion, and electrolytes reduce surface energy as concentration increases, by tens of mJ/m². All of these surface energy changes are qualitatively consistent with changes in fracture surface energy caused by the same variables. (quartz, surface energy, adsorption, fracture).
J. Geophys. Res., Red, Paper 3B1258

Oceanography

4765 Surface Waves
MEASUREMENT OF BREAKING WAVES BY A SURFACE JUMP METER
M. S. Longuet-Higgins (Institute of Oceanographic Sciences, Wormley, England GU8 5UB) and N. D. Smith

Quantitative information on the strength and size-distribution of whitecaps in a given wave field is very scarce. During the MARSEN field experiment, observations of surface elevation were made with a capacitance-wire wave recorder attached to a free-floating spar-buoy. Automatic analysis of the records ...

Particles and Fields—Interplanetary Space

[illegible]

Particles and Fields—Ionosphere

[illegible]

Nominations for Medals and Awards

William Bowie Medal. Awarded for outstanding contributions to fundamental geophysics and for unselfish cooperation in research.

Maurice Ewing Medal. Honors an individual who has led the way in understanding the physical, geophysical, and geological processes in the ocean; who is a leader in ocean engineering, technology, and instrumentation; or who has given distinguished service to the marine sciences.

Robert E. Horton Medal. Given for outstanding contributions to the geophysical aspects of Hydrology.

James B. Macelwane Awards. Up to three awards are given each year for significant contributions to the geophysical sciences by a young scientist of outstanding ability. Recipients must be less than 36 years old.

Letters of nomination outlining significant contributions and curriculum vitae should be sent directly to the appropriate committee chairmen: *Bowie Medal* - Eugene M. Shoemaker, U.S. Geological Survey, 2255 Gemini Drive, Flagstaff, AZ 86001; *Ewing Medal* - Robert O. Reid, Department of Oceanography, Texas A&M University, College Station, TX 77843; *Horton Medal* - R. Allan Freeze, Department of Geological Sciences, University of British Columbia, Vancouver, B.C., Canada V6T 1W5; *Macelwane Award* - J. Freeman Gilbert, IGPP A-025, University of California/San Diego, La Jolla, CA 92093.

Deadline for Nominations is November 1, 1983.

5535 Interactions between waves and particles
PEDERSEN DENSITY DRIFT INSTABILITIES
S. P. Gary (ESS-8, Los Alamos National Laboratory, Los Alamos, NM, 87545) and T. E. Cole

This paper describes the linear kinetic theory of electrostatic drift ...

Particles and Fields—Magnetosphere

[illegible]

5790 General (Ion Coupling to the Turbulent Magnetosheath Bulk Flow)
ON THE COUPLING OF TEST IONS TO MAGNETOPLASMA FLOWS THROUGH TURBULENCE
A.L. Brinca (Max-Planck-Institut für extraterrestrische Physik, 8046 Garching b. München, W-Germany)

The evolution in velocity and configuration spaces of ions injected into a flowing turbulent magnetoplasma is studied from a test particle viewpoint. Numerical integration of the equations of motion for several types of fluctuations and injection velocities permits assessing the effectiveness of the turbulence in forcing the ensemble average velocity of the ions to approach the bulk flow velocity. ...

Tectonophysics

[illegible]

General or Miscellaneous

[illegible]

... In addition, the model is insensitive to global sea level variations (related to tectonics and not ice volume) which are well correlated with paleoclimatic data. Additional climatic forcing factors, such as increased atmospheric CO_2 correlated with these sea level variations, may be required to explain the Cretaceous climate.
J. Geophys. Res., Green, Paper 3C1175

Geophysical Research Letters

Volume 10 Number 10 October 1983

Corrections